

**REMARKS**

Claims 1, 4-18, 32-35 and 37-55 are pending in this application, of which claims 7-14 and 33 have been withdrawn pursuant to a Restriction Requirement and an Election of Species Requirement. Applicants reserve the right to file a divisional application to pursue the subject matter of claims 19-32 and 36. By this Amendment, claims 1 and 34 are amended, claims 2-3, 19-32 and 36 are canceled, and claims 37-55 are added. No new matter is added.

**I. Amendments**

New independent claim 37 reads on the elected invention and species. New dependent claims 38-39 are directed to features of the gas decomposer. New dependent claims 40-55 depend from claim 37 and correspond to claims 4-18 and 33, respectively.

**II. The Claims Are Patentable Over the Applied References****A. Harutyunyan**

The Patent Office rejects claims 1, 4, 6 and 15-18 under 35 U.S.C. §102(b) over U.S. Patent Application Publication No. 2001/0053344 to Harutyunyan et al. (Harutyunyan). Applicants respectfully traverse the rejection.

Regarding independent claim 1, Harutyunyan fails to disclose "a synthesizing portion that is placed in the reaction tube and continuously supplied with the decomposed carbon-containing raw material, which has been carried on the gas flow to an outside of the gas decomposer," and "the gas decomposer is a molecular sieve."

Harutyunyan discloses an apparatus 10 for producing elongated carbonaceous articles that includes chamber 11 having heating element 12, inlet port 18, exit port 20, magnetic field generating device 40, and a catalyst bed 26 that has substrate 30 and catalyst 34. In operation, a carbon precursor from carbon-containing precursor source 16 enters the inlet port 18 in gaseous form (Fig. 1); paragraph [0031]) to form carbonaceous articles on substrate 30. The

magnetic field generating device 40 produces a magnetic field that serves to prevent the catalyst from becoming an impurity in the carbonaceous articles. The Office Action fails to identify what element of Harutyunyan corresponds to the claimed synthesizing portion, but alleges that the substrate 30 corresponds to the recited gas decomposer.

Harutyunyan fails to disclose the claimed synthesizing portion because, in Harutyunyan, the carbonaceous articles are grown at the sites of catalyst 34 on substrate 30. Under the Office Action's interpretation of Harutyunyan, the carbonaceous articles are thus grown on the gas decomposer, and therefore there is no element corresponding to the claimed synthesizing portion that is "continuously supplied with the decomposed carbon-containing raw material, which has been carried on the gas flow to an outside of the gas decomposer."

Harutyunyan fails to disclose the claimed gas decomposer because Harutyunyan discloses that the gas decomposer is formed of materials such as a ceramic (paragraph [0032]), which is not a molecular sieve. The Examiner is directed to the attached Wikipedia articles on zeolite (Exhibit A) and molecular sieve (Exhibit B), which discuss the characteristics of molecular sieves.

For the foregoing reasons, Applicants request withdrawal of the rejection.

**B. Wen**

The Office Action rejects claims 1 and 4-5 under 35 U.S.C. §102(b) over U.S. Patent No. 5,702,532 to Wen et al. (Wen). Applicants respectfully traverse the rejection.

Regarding independent claim 1, Wen fails to disclose "a gas decomposer that is placed in the reaction tube to decompose the carbon-containing raw material upon contact with the gas flow" and "the gas decomposer is a molecular sieve."

Wen discloses a metal organic-chemical vapor-phase deposition (MOCVD) reactor chamber 20 having a rotatable susceptor 21 having wafers/substrates 23 and a heat source 25 (Fig. 1). In operation, two different precursors, precursors 1 and 2, are input through

manifolds 17 and 16, respectively (Fig. 1; col. 4, lines 26-40) to produce an indium antimonide epitaxial layer on the wafers 23. The Office Action cites to the precracking zone 28 as corresponding to the recited gas decomposer.

Wen fails to disclose the claimed gas decomposer because the precracking zone 28 in Wen is a space or void (there is no structure at this location), and does not correspond to any structure that corresponds to the claimed gas decomposer "that is placed in the reaction tube to decompose the carbon-containing raw material upon contact with the gas flow."

Further, Wen fails to disclose a gas decomposer that is a molecular sieve because, as the precracking zone 28 is a space or void, it cannot have the structure of a molecular sieve.

For the foregoing reasons, Applicants request withdrawal of the rejection.

**C. Someya**

The Office Action rejects claims 1-4, 6, 15-18 and 34-36 under 35 U.S.C. §102(e) over U.S. Patent Application Publication No. 2003/0147801 to Someya et al. (Someya). Applicants respectfully traverse the rejection.

Regarding independent claim 1, Someya fails to disclose "a synthesizing portion that is placed in the reaction tube and continuously supplied with the decomposed carbon-containing raw material, which has been carried on the gas flow to an outside of the gas decomposer" and "the gas decomposer is a molecular sieve." Regarding independent claim 34, Someya fails to disclose "a gas decomposer . . . comprising a porous material that is a molecular sieve."

Someya discloses a process for producing aligned carbon nanotube films (abstract). The process uses a porous ceramic substrate (paragraphs [0016] - [0018]) and includes the steps of: coating the substrate by a non-catalytic element in a first step (paragraphs [0019] - [0020]); coating the substrate with a catalytic metallic element in a second step (paragraph [0021]); and depositing a carbon compound to form the carbon nanotube film in a

third step (paragraph [0032]). The carbon compound used is any type able to form carbon nanotubes in the presence of a suitable catalyst (paragraph [0032]). Pyrolysis is the most common way for decomposing the carbon compound (paragraph [0032]). While the Office Action alleges that element 2 of Fig. 4 corresponds to the claimed gas decomposer, in Example 5, a masking tape is element 2 and is used to mask a substrate 1 made of silica-alumina before aluminum deposition (Fig. 4; paragraph [0047]).

Someya fails to disclose or suggest a synthesizing portion because Someya discloses that the carbon nanotubes are grown on the substrate that is coated by a catalyst. Thus, there is no element corresponding to the claimed synthesizing portion that is "continuously supplied with the decomposed carbon-containing raw material, which has been carried on the gas flow to an outside of the gas decomposer."

Someya further fails to disclose a gas decomposer that is a molecular sieve because the masking tape 2 cited by the Office Action as corresponding to the gas decomposer is not a molecular sieve.

For the foregoing reasons, Applicants request withdrawal of the rejection.

#### **D. New Claims**

New independent claim 37 reads on the elected species and invention. New claim 37 recites a gas decomposer that is a zeolite-based material. Thus, independent claim 37 and those claims dependent on independent claim 37 are patentable over the applied references because none of the applied references disclose a gas decomposer that is a zeolite material. The Examiner is directed to Exhibit A, a Wikipedia article on zeolite.

#### **III. Conclusion**

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance are earnestly solicited.



Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,



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Attachment:

Exhibit A  
Exhibit B  
Amendment Transmittal

Date: March 13, 2008

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# Zeolite

From Wikipedia, the free encyclopedia

**Zeolites** (Greek, *zein*, "to boil"; *lithos*, "a stone") are hydrated aluminosilicate minerals and have a micro-porous structure.

The term was originally coined in the 18th century by a Swedish mineralogist named Axel Fredrik Cronstedt who observed, upon rapidly heating a natural mineral, that the stones began to dance about as the water evaporated. Using the Greek words which mean "stone that boils," he called this material zeolite.

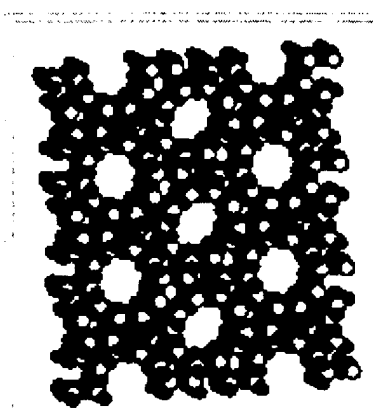
More than 150 zeolite types have been synthesized and 48 naturally occurring zeolites are known. Zeolites have an "open" structure that can accommodate a wide variety of cations, such as  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and others. These positive ions are rather loosely held and can readily be exchanged for others in a contact solution. Some of the more common mineral zeolites are: analcime, chabazite, heulandite, natrolite, phillipsite, and stilbite. An example mineral formula is:  $\text{Na}_2\text{Al}_2\text{Si}_3\text{O}_{10} \cdot 2\text{H}_2\text{O}$ , the formula for natrolite.

Natural zeolites form where volcanic rocks and ash layers react with alkaline groundwater. Zeolites also crystallized in post-depositional environments over periods ranging from thousands to millions of years in shallow marine basins. Naturally occurring zeolites are rarely pure and are contaminated to varying degrees by other minerals, metals, quartz or other zeolites. For this reason, naturally occurring zeolites are excluded from many important commercial applications where uniformity and purity are essential.

Zeolites are the aluminosilicate members of the family of microporous solids known as "molecular sieves". The term molecular sieve refers to a particular property of these materials, i.e. the ability to selectively sort molecules based primarily on a size exclusion process. This is due to a very regular pore structure of molecular dimensions. The maximum size of the molecular or ionic species that can enter the pores of a zeolite is controlled by the diameters of the tunnels. These are conventionally defined by the ring size of the aperture, where, for example, the term "8ring" refers to a closed loop that is built from 8 tetrahedrally coordinated silicon (or aluminium) atoms and 8 oxygen atoms. These rings are not always perfectly flat and symmetrical due to a variety of effects, including strain induced by the bonding between units that are needed to produce the overall structure, or coordination of some of the oxygen atoms of the rings to cations within the structure. Therefore, the pore openings for all rings of one size are not identical.



Zeolite



The micro-porous molecular structure of a zeolite, ZSM-5

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## Sources

Conventional open pit mining techniques are used to mine natural zeolites. The overburden is removed to allow access to the ore. The ore may be blasted or stripped for processing by using tractors equipped with ripper blades and front-end loaders. In processing, the ore is crushed, dried, and milled. The milled ore may be air-classified as to particle size and shipped in bags or bulk. The crushed product may be screened to remove fine material when a granular product is required, and some pelletized products are produced from fine material. Producers also may modify the properties of the zeolite or blend their zeolite products with other materials before sale to enhance their performance.

Currently, the world's annual production of natural zeolite is about 4 million tons. Of this quantity, 2.6 million tons are shipped to Chinese markets to be used in the concrete industry. Eastern Europe, Western Europe, Australia, and Asia are world leaders in supplying the world's demand for natural zeolite. By comparison, only 57,400 metric tons (source: U.S. Geological Survey, 2004) of zeolite (only 1% of the world's current production) is produced in North America; only recently has North America realized the potential for current and future markets.

There are several types of synthetic zeolites that form by a process of slow crystallization of a silica-alumina gel in the presence of alkalis and organic templates. One of the important processes used to carry out zeolite synthesis is sol-gel processing. The product properties depend on reaction mixture composition, pH of the system, operating temperature, pre-reaction 'seeding' time, reaction time as well as the templates used. In sol-gel process, other elements (metals, metal oxides) can be easily incorporated. The silicalite sol formed by the hydrothermal method is very stable. Also the ease of scaling up this process makes it a favorite route for zeolite synthesis.

Synthetic zeolites hold some key advantages over their natural analogs. The synthetics can, of course, be manufactured in a uniform, phase-pure state. It is also possible to manufacture desirable zeolite structures which do not appear in nature. Zeolite A is a well-known example. Since the principal raw materials used to manufacture zeolites are silica and alumina, which are among the most abundant mineral components on earth, the potential to supply zeolites is virtually unlimited. Finally, zeolite manufacturing processes engineered by man require significantly less time than the 50 to 50,000 years



prescribed by nature. Disadvantages include the inability to create crystals with dimensions of a comparable size to their natural counterparts.

## Uses

### Commercial and Domestic

Zeolites are widely used as ion-exchange beds in domestic and commercial water purification, softening, and other applications. In chemistry, zeolites are used to separate molecules (only molecules of certain sizes and shapes can pass through), as traps for molecules so they can be analyzed.

Zeolites have the potential of providing precise and specific separation of gases including the removal of  $\text{H}_2\text{O}$ ,  $\text{CO}_2$  and  $\text{SO}_2$  from low-grade natural gas streams. Other separations include: noble gases,  $\text{N}_2$ ,  $\text{O}_2$ , freon and formaldehyde. However at present, the true potential to improve the handling of such gases in this manner remains unknown.

### Petrochemical industry

Synthetic zeolites are widely used as catalysts in the petrochemical industry, for instance in fluid catalytic cracking and hydro-cracking. Zeolites confine molecules in small spaces, which causes changes in their structure and reactivity. The hydrogen form of zeolites (prepared by ion-exchange) are powerful solid-state acids, and can facilitate a host of acid-catalyzed reactions, such as isomerisation, alkylation, and cracking. Catalytic cracking uses a furnace and reactor. First crude oil distillation fractions are heated in the furnace and passed to the reactor. In the reactor the crude meets with a catalyst such as zeolite. It goes through this step three times, each time getting cooler. Finally it reaches a step known as separator. The separator collects recycled hydrogen. Then it goes through a fractionator and becomes the final item.

### Nuclear Industry

Zeolites have uses in advanced reprocessing methods, where their micro-porous ability to capture some ions while allowing others to pass freely allow many fission products to be efficiently removed from nuclear waste and permanently trapped. Equally important are the mineral properties of zeolites. Their alumino-silicate construction is extremely durable and resistant to radiation even in porous form. Additionally, once they are loaded with trapped fission products, the zeolite-waste combination can be hot pressed into an extremely durable ceramic form, closing the pores and trapping the waste in a solid stone block. This is a waste form factor that greatly reduces its hazard compared to conventional reprocessing systems. [1]

### Agriculture

In agriculture, clinoptilolite (a naturally occurring zeolite) is used as a soil treatment. It provides a source of slowly released potassium. If previously loaded with ammonium, the zeolite can serve a similar function in the slow release of nitrogen. Cuban studies in the emerging field of "zeoponics" suggest that some crops may be grown in 100% zeolite or zeolite mixtures in which the zeolite is previously loaded or coated with fertilizer and micronutrients. Zeolites can also act as water moderators, in which they will absorb up to 55% of their weight in water and slowly release it under plant demand.

This property can prevent root rot and moderate drought cycles.

A potting soil with 12% clinoptilolite was shown to harvest morning dew and return it to the plant roots for reuse. The same bed was able to grow a Jerico strain of leaf lettuce in a sub tropical climate without external water and daytime temperatures exceeding 85 °F. This produce did not bolt and went full term before setting seeds. It also has been shown that certain zeolites can reduce nitrates and nitrites to more plant usable free nitrogen by ion exchange.

## **Animal Welfare**

In Concentrated Animal Growing facilities, the addition of as little as 1% of a very low sodium clinoptilolite was shown to improve feed conversion, reduce airborne ammonia up to 80%, act as a mycotoxin binder and improve bone density. See US Patents 4,917,045 and 6,284,232. Can be used in general odor elimination for all animal odors.

## **Medical**

Zeolite-based oxygen generation systems are widely used to produce medical grade oxygen. The zeolite is used as a molecular sieve to create purified oxygen from air, in a process involving the absorption of undesired gases and other atmospheric components, leaving highly purified oxygen and up to 5% argon. Zeolite is also the active component in QuikClot, an emergency coagulant.

## **Heating and refrigeration**

Zeolites can be used as solar thermal collectors and for adsorption refrigeration. In these applications, their high heat of adsorption and ability to hydrate and dehydrate while maintaining structural stability is exploited. This hygroscopic property coupled with an inherent exothermic reaction when transitioning from a dehydrated to a hydrated form (heat adsorption), make natural zeolites effective in the storage of solar and waste heat energy.

## **Detergents**

The largest outlet for synthetic zeolite is the global laundry detergent market. This amounted to 1.44 million metric tons per year of anhydrous zeolite A in 1992.

## **Construction**

Synthetic zeolite is also being used as an additive in the production process of warm mix asphalt concrete. The development of this application started in Europe (Germany) in the 1990s. It helps by decreasing the temperature level during manufacture and laying of asphalt concrete, resulting in lower consumption of fossil fuels, thus releasing less carbon dioxide, aerosols and vapours. Other than that the usage of synthetic zeolite in hot mixed asphalt leads to easier compaction and to a certain degree allows cold weather paving and longer hauls.

When added to Portland Cement as a Pozzolan, it can reduce chloride permeability and improve workability. It reduces weight and helps moderate water content while allowing for slower drying which improves break strength.<sup>[1]</sup>

## Gemstones

Thomsonites, one of the rarer zeolite minerals, have been collected as gemstones from a series of lava flows along Lake Superior in Minnesota and to a lesser degree in Michigan, U.S.A.. Thomsonite nodules from these areas have eroded from basalt lava flows and are collected on beaches and by scuba divers in Lake Superior.

These thomsonite nodules have concentric rings in combinations of colors, black, white, orange, pink, red and many shades of green. Some nodules have copper as inclusions and rarely will be found with copper "eyes". When polished by a lapidary the thomsonites sometimes display chatoyancy.<sup>[2]</sup>

## Aquarium keeping

Zeolites are marketed by pet stores for use as a filter additive in aquariums. In aquariums, zeolites can be used to absorb ammonia and other nitrogenous compounds. However, due to the high affinity of some zeolites for calcium, they may be less effective in hard water and may deplete calcium. Zeolite filtration is used in some marine aquaria to keep nutrient concentrations low for the benefit of corals adapted to nutrient-depleted waters.

## Space hardware testing

Zeolite can be used as a molecular sieve in cryosorption pumps for rough pumping of vacuum chambers which can be used to simulate space-like conditions in order to test hardware bound for space.

## Zeolite mineral species

The Zeolite family includes

- |                  |                 |                      |
|------------------|-----------------|----------------------|
| ■ Amicite        | ■ Gmelinite     | ■ Paulingite         |
| ■ Analcime       | ■ Gobbinsite    | ■ Pentasil           |
| ■ Barrerite      | ■ Gonnardite    | ■ Perlialite         |
| ■ Bellbergite    | ■ Goosecreekite | ■ Phillipsite        |
| ■ Bikitaite      | ■ Harmotome     | ■ Pollucite          |
| ■ Boggsite       | ■ Herschelite   | ■ Scolecite          |
| ■ Brewsterite    | ■ Heulandite    | ■ Sodium Dachiardite |
| ■ Chabazite      | ■ Laumontite    | ■ Stellerite         |
| ■ Clinoptilolite | ■ Levyne        | ■ Stilbite           |
| ■ Cowlesite      | ■ Maricopaite   | ■ Tetranatrolite     |
| ■ Dachiardite    | ■ Mazzite       | ■ Thomsonite         |
| ■ Edingtonite    | ■ Merlinoite    | ■ Tschernichite      |
| ■ Epistilbite    | ■ Mesolite      | ■ Wairakite          |
| ■ Erionite       | ■ Montesommaite | ■ Wellsite           |
| ■ Faujasite      | ■ Mordenite     | ■ Willhendersonite   |
| ■ Ferrierite     | ■ Natrolite     | ■ Yugawaralite       |
| ■ Garronite      | ■ Offretite     |                      |
| ■ Gismondine     | ■ Paranatrolite |                      |

## Notes

- <sup>^</sup> Dypayan Jana, *CLINOPTILOLITE – A PROMISING POZZOLAN IN CONCRETE*, <http://www.cmc-concrete.com/CMC%20Seminars/2007%20ICMA%20Zeolite.pdf>
- <sup>^</sup> <http://www.cst.cmich.edu/users/dietr1rv/thomsonite.htm> R. V. Dietrich, 2006, Thomsonite

## References

- Zeolites in Sedimentary Rocks. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
- Natural and Synthetic Zeolites. U.S. Bureau of Mines Information Circular 9140, 1987.
- La roca magica: Uses of natural zeolites in agriculture and industry

Frederick A. Mumpton. National Academy of Sciences Vol. 96, Issue 7, 3463-3470, March 30, 1999 Abstract

- “Zeolite-water close cycle solar refrigeration ; numerical optimisation and field-testing”, Jean-Baptiste Monnier; Dupont, M. Proc. Annu. Meet. - Am. Sect. Int. Sol. Energy Soc. ; Vol/Issue: 6 pp 181-185; American Solar Energy Society meeting; 1 Jun 1983; Minneapolis, MN, USA

## See also

List of minerals

## External links

- Database of Zeolite Structures
- The Synthesis Commission of the International Zeolite Association
- British Zeolite Association
- U.S. Geological Survey, References on Zeolites

Retrieved from "<http://en.wikipedia.org/wiki/Zeolite>"

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# Molecular sieve

From Wikipedia, the free encyclopedia

A **molecular sieve** is a material containing tiny pores of a precise and uniform size that is used as an adsorbent for gases and liquids.

Molecules small enough to pass through the pores are adsorbed while larger molecules are not. It is different from a common filter in that it operates on a molecular level. For instance, a water molecule may be small enough to pass through while larger molecules are not. Because of this, they often function as a desiccant. A molecular sieve can adsorb water up to 22% of its own weight.<sup>[1]</sup>

Often they consist of aluminosilicate minerals, clays, porous glasses, microporous charcoals, zeolites, active carbons, or synthetic compounds that have open structures through which small molecules, such as nitrogen and water can diffuse.

Molecular sieves are often utilized in the petroleum industry, especially for the purification of gas streams and in the chemistry laboratory for separating compounds and drying reaction starting materials. The mercury content of natural gas is extremely harmful to the aluminum piping and other parts of the liquefaction apparatus - silica gel is used in this case.

Methods for regeneration of molecular sieves include pressure change (as in oxygen concentrators), heating and purging with a carrier gas (as when used in ethanol dehydration), or heating under high vacuum.

## Contents

- 1 Adsorption capabilities<sup>[2][3]</sup>
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## Adsorption capabilities<sup>[2][3]</sup>

- 3A (pore size 3 Å): Adsorbs  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ , (not  $\text{C}_2\text{H}_6$ ), good for drying polar liquids.
- 4A (pore size 4 Å): Adsorbs  $\text{H}_2\text{O}$ ,  $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{H}_2\text{S}$ ,  $\text{C}_2\text{H}_4$ ,  $\text{C}_2\text{H}_6$ ,  $\text{C}_3\text{H}_6$ ,  $\text{EtOH}$ . Will not adsorb  $\text{C}_3\text{H}_8$  and higher hydrocarbons. Good for drying nonpolar liquids and gases.
- 5A (pore size 5 Å): Adsorbs normal (linear) hydrocarbons to  $\text{n-C}_4\text{H}_{10}$ , alcohols to  $\text{C}_4\text{H}_9\text{OH}$ , mercaptans to  $\text{C}_4\text{H}_9\text{SH}$ . Will not adsorb isocompounds or rings greater than  $\text{C}_4$ .
- 10X (pore size 8 Å): Adsorbs branched hydrocarbons and aromatics. Useful for drying gases.
- 13X (pore size 10 Å): Adsorbs di-n-butylamine (not tri-n-butylamine). Useful for drying HMPA.

## See also

Some of the many types of molecular sieves are:

- Activated carbon
- Desiccant
- Lime (mineral)
- Silica gel
- Zeolite

## References

1. ^ <http://www.molecularsieve.org/>
2. ^ Feiser and Feiser, Reagents for Organic Synthesis, Vol. 1, Wiley, New York, 1967, p. 703
3. ^ Breck, D.W. J. Chem. Ed., 41, 678 (1964)

## External links

- Sieves put a lid on greenhouse gas
- molecular sieve patents
- Molecular sieve faq.
- An Open Cycle Molecular Sieve Dehydration System.
- Sigma-Aldrich

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